



## **The STEPS Difference**

### **16 years of attracting girls to careers in science, technology, engineering and math**

by Brenda S. Puck and Wendy R. Stary

The University of Wisconsin-Stout, in partnership with the Society of Manufacturing Engineering Education Foundation (SME-EF), initiated an outreach program in 1997 for girls entering the seventh grade. The original impetus for STEPS program founder, Pete Heimdahl, and his colleagues related to a lack of women available to teach in engineering education programs. It was decided that middle school aged girls would be the appropriate candidates from both a human development and academic perspective.<sup>1,2</sup>

“STEPS for Girls” is a one-week introduction to the world of manufacturing. Manufacturing provides an applied experience that allows the girls to see a direct connection between science, technology, engineering and math (STEM), and how professionals use them in engineering-related careers. For 10 years, the girls manufactured radio-controlled model airplanes from raw materials. During the past five years, the participants have produced radio-controlled model boats. Next year, the participants will build battery-powered robots. Each participant creates her own product, tests it and takes it home.

The components are fabricated in various laboratory activities using real production equipment. “STEPS for Girls” participants gain direct hands-on experience in mathematics, physics, chemistry, packaging, computer-aided design (CAD), rapid prototyping, computer-aided manufacturing, CNC machining, metals casting, plastics processing, robotics, web page development and printing.<sup>3</sup>

“Advanced Steps” is a one-week program that reinforces the concepts presented in the first STEPS program; provides an advanced engineering design and problem-solving experience; and offers more specific information about career opportunities in STEM. Team problem-solving activities are inspired by the FIRST LEGO League (FLL) competition strategy, and use the LEGO Mindstorms robotic technology.<sup>4</sup> The advanced program has been offered

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four times during the past six years. Participants are alumnae from the program at the UW-Stout or one of the institutions that have replicated the STEPS concept.

Industry, university and SME-EF support are keys to the success of this program. Initially free to all participants, the program now charges \$450 for the week of activities. This tuition rate is about one-half of the per-participant cost to produce the program. The seventh grade outreach program, which completed its 15th program summer in 2011, now has 2,400 female graduates. Advanced STEPS has 160 alumnae. Twenty-five percent of participants in each program year receive donor supported scholarships due to low income status. On Aug. 2 STEPS will celebrate its 16<sup>th</sup> anniversary.

### **STEPS for Girls: A brief overview**

STEPS for Girls was designed to be a set of intense immersion activities that provides technical (process and production systems), developmental (personal development and leadership) and recreational experiences. From arrival of the participants on Sunday afternoon until departure on Thursday afternoon, there are 52.5 hours of scheduled time outside routine meals. The balance among the various types of activities includes:

1. Technical activities: 20 hours
2. Developmental activities: 18 hours
3. Recreational activities: 14.5 hours

Technical activities are designed around the manufacture of a radio-controlled model boat. The boat is finally assembled in the STEPS Production Lab after other lab activities produce parts as “subcontractors” or provide analyses and information as “consultants.” Several of the activities in the boat production are:

- Subcontractors:
  - Foundry: Casting aluminum steering console.
  - Plastics: Thermoforming deck, hull and electronics cover.



- Packaging: Automated fabrication of a corrugated paper container to protect and communicate.
- Electronics: Production of wiring harness.
- Consultants:
  - Physics: Theory of buoyancy.
  - Chemistry: Different ways to power boats.
  - Math: Analysis of weight and balance.
  - CADD: Manipulation and modification of 2-D and 3-D CAD visualization renderings of the boat.
  - Automation and robotics: Computer integrated machining and manufacturing concepts.
  - IT: Assembly of a computer, discover and analysis of information communication systems concepts.
  - Web design: Development of web pages, and use of software to communicate information.
  - Graphic arts: Produce a newsletter, and screen print a tote bag to carry artifacts created at STEPS.

The activities provide an interesting view of the excitement experienced by those who pursue a career in science, technology, engineering and math and what it takes to achieve and succeed in one. All of these activities are presented by UW-Stout STEM faculty members or professionals in the field, most of whom are women.

The culminating technical activity is the Wednesday and Thursday afternoon regatta. The participants then control their boat in the STEPS pool, which is 60 feet long by 10 feet wide by nine inches deep. Several activities have been created to allow the participants to master the skill of maneuvering their boat using radio control units. A pair of participants attempts to rescue a Bratz boy doll before a radio-controlled shark gets him in the final activity. Bleachers are provided for spectators.



## **Advanced STEPS: A brief overview**

Advanced STEPS for Girls was conducted on the UW-Stout campus for the first time in the summer of 2006. The one-week experience was offered to alumnae of the seventh grade STEPS program of 2003. The goals of the Advanced STEPS program concept developed out of a request from alumnae and their parents for an opportunity to reinforce the career message of the seventh grade STEPS program for those who were still interested. This experience provides another opportunity to significantly influence the selection of STEM as a participant's career choice. It also offers young women an engineering design and problem-solving experience.

The week focuses on an unstructured design experience for the Advanced STEPS participants. The design activity is deliberately designed to be “messy,” as all design experiences are—with multiple solutions possible. The LEGO Mindstorms robotic technology is the foundation upon which the technical activities of the 10th grade experience are based. As 15-year-olds, the advanced participants are more likely to possess the cognitive skills appropriate for an advanced engineering design experience than when they were 12. The week is spent teaching the concepts of robotics and controls to the participants for them to be able to accomplish a major project by the week's end.

There are four instructional staff members, LEGO professors and four LEGO team mentors required for staffing this week-long summer experience. The LEGO professors conducted the instructional activities, and the LEGO mentors, all of whom are STEPS alumnae or female college-age students in one of the STEM programs at the UW-Stout. One LEGO mentor is assigned to a team of participants. The mentors are responsible for guiding the teams through the brainstorming, problem solving and technical matters of robot design and programming. The team members are responsible for developing their own solutions to the design project.

The project, created in true Rube Goldberg style, is a fun problem to be addressed autonomously by each of the four teams. The Official Rube Goldberg website defines a Rube Goldberg as “a comically involved, complicated invention, laboriously contrived to perform a



simple operation.”<sup>5</sup> Rube Goldberg was a Pulitzer Prize winning cartoonist, sculptor and author best known for hilariously depicted drawings of his “inventions.”

The first design project in 2006, “Rube’s Smart House,” had the context that a family would be out of town for a week and needed to have certain household functions occur in the house while they were gone. During the program from 2007-2009, a challenge theme was chosen from the FIRST LEGO League (FLL) archives.<sup>6</sup> The design project was introduced to the participants at the end of the first day.

Each team has access to its own 4 x 8 foot table that remains from the FIRST LEGO League (FLL) competition hosted by the UW-Stout each year. The design project challenge requires the participants to analyze the design problem, research concepts related to the problem, brainstorm ideas, create and develop solutions and test their solution in a friendly competition with the other teams. The teams also present their solutions to a team of professionals. The professionals mentor the teams through assessment and supportive counsel.

Several instructional activities, conducted by the LEGO professors, help the participants learn how to program the LEGO Mindstorms control unit, function as a team in creative problem solving, use sensors available on the LEGO Mindstorms control unit, and build mechanical mechanisms using LEGO building sets. After this initial day of activities, the teams are turned loose at designing their solutions to the design project for the remainder of the design time. The energy and excitement of the teams is contagious.

In addition to the assessment and mentoring of teamwork, programming and design, the teams’ best performance in solving the design challenge is factored into the awards process. Awards are given in the following classifications: Director’s Award (the strongest overall in all categories), Programming and Design Award, Judge’s Award (most improved team during the course of the week), Teamwork Award and Gracious Professionalism Awards (given to one member of each team that exemplified the spirit of gracious professionalism).

As in the STEPS program previously discussed, adequate time is spent in recreational and developmental activities, including the Adventure Challenge team skills course, swimming,



recreation centers and industry tours. It is important to provide a balanced approach of recreational and developmental activities along with the creative design experience provided through the project.

### **Junior counselors and lab assistants**

Based on the success of Advanced STEPS, two new components to the STEPS for Girls program were initiated. In 2007, STEPS introduced the junior counselor position as a leadership opportunity for the 10th grade alumnae to mentor to the younger participants. An alumna applies for a one-week assignment. The STEPS lab assistant position for 11th and 12th grade alumnae was introduced in 2008. The lab assistant opportunity allows the more mature alumnae to learn technical skills while assisting faculty and staff, and mentoring to the younger participants. The lab assistants apply to serve a two or four-week assignment.

### **The history behind STEPS**

The STEPS for Girls program was created 15 years ago due to the inability of the program founders to find women to teach at the post-secondary level in engineering related fields. Attentive to the importance of role models to the development of perceptions in human development, they decided to “grow their own.”<sup>7</sup> The STEPS mission is to reach girls and young women with solid information about the excitement of a STEM career and what it takes to achieve and succeed in one. A goal toward achieving this mission is to inspire participants to prepare themselves for these careers by taking the appropriate courses in middle and high school. The program motto of “It’s OK to be cute and smart” serves to increase self-esteem and empower participants toward this goal.

High school girls want careers that are relevant and rewarding, make a difference and pay well.<sup>8</sup> Unfortunately, they are often given the misconception about engineering that it is a stressful occupation requiring high achievement in math and science. This perception needs to change if more young women are to be recruited into the engineering fields. Positive influence in this direction can come from the true stories of women engineers making a good living while creatively solving real-life problems and positively impacting society along the way. Beyond



witnessing the successes of others, women's participation in science and engineering is rooted in current and historic participation in these fields, differences in educational attainment for women, and achievement in precollege courses.<sup>9</sup>

There are plenty of potential female candidates out there. The 2010 Bureau of Labor Statistics report indicates that women make up 50.7% of all U.S. residents with 1.5 million of these women having graduated from high school in 2010.<sup>10</sup> Seventy-four percent of the 2010 female high school graduates enrolled in college. Yet, using the latest Engineering Workforce Commission data from 2008, about 1.2% of them enrolled in engineering fields. In addition, about 5.2% of all U.S. female high school graduates enroll in natural science baccalaureate programs each year. These statistics equate to an extremely large proportion of highly qualified women not entering engineering, technology or natural science career choices.<sup>11</sup>

One possible explanation for the shortfall of women entering engineering fields is that masculine norms or codes of conduct, which are not conducive to diversity, dominate the workplace culture and leave women feeling like outsiders.<sup>12</sup> Moreover, the current low numbers of women in science and engineering have the potential to lead to stereotyping of performance, difficulty achieving credibility amongst peer or administrators, and a lack of mentoring for future female engineers.<sup>13</sup>

In most career fields, women's participation has increased during the past two decades.<sup>14, 15</sup> Since 1989, more women are pursuing careers in social sciences and biosciences. Although, women are still earning fewer degrees in physical sciences and math, a recent American Association of Engineering Societies (AAES) survey shows that women receiving bachelor's of science degrees in engineering increased in number and percentage for the first time in three years.

### **The study**

The method used is a longitudinal study of survey data collected at intervals of pre-experience, post-experience and 10th grade. The surveys for pre and post-experience were administered electronically or via paper to the young women while they were on campus. The first three years



of participants, alumnae from 1997-1999, were administered a longitudinal survey via paper through the mail in 2005. For the upcoming longitudinal surveys, electronic methods will be introduced for distribution and collection of results.

### **The findings: significant impact**

The 2011 STEPS pre and post-experience surveys reveal that when STEPS participants graduate from high school or college, they have a strong interest in pursuing careers in the fields of science, technology and engineering. This interest is enhanced by participation in STEPS. The participants interest in these areas increased by 5% and 15% percent, respectively, on the post experience survey. The participant's survey responses also reveal a slight increase in interest for careers in math. In preparation for these career endeavors, the participants also expressed more interest in taking courses related to STEM.

The first program graduates are now in their mid to late 20s. Follow-up surveys of the first three years of participants indicated significant impacts on their career pursuits. The survey was focused on determining the college program of study chosen by the STEPS classes of 1997-1999. It also sought to determine the influence STEPS had in their program of study. The average influence rank assigned by the graduates was 3.5 out of 5, indicating that they felt STEPS had an important influence on their career choice. The percentages of graduates pursuing an engineering or scientific program of study vary from a combined sum of 33 to 45%.

According to the follow-up survey administered to the STEPS graduates, 11.5% of the survey respondents have indicated a program of study in engineering and technology. This is an extremely significant finding. It indicates that STEPS graduates are 2.9 times more likely to pursue engineering or technology careers when compared to the national average of 3.9% in 2004. If the 1.5 million female high school graduates enrolled in engineering and technology programs at the same rate as STEPS graduates, the number would exceed the total engineering and technology annual enrollment, which was reported at about 111,006 in 2008.<sup>16</sup>

According to the follow-up survey administered to the STEPS graduates, 25% of the survey respondents have indicated a program of study in natural sciences. This is also a



significant finding. It indicates that STEPS graduates are 2.3 times more likely to pursue a scientific career pursuit when compared to the 2004 national average of 10.9% of high school graduates.

The next longitudinal survey to help measure the long-term impact of the STEPS program is being developed for online implementation during this summer. The testimonials received from alumnae continue to provide qualitative data to support the positive impact of the program on the future choices that these girls and young women make in the STEM areas. The following quote is an example of this feedback:

“Since the first time I attended STEPS, I have known that I want to go into engineering. Without attending STEPS, I do not know where I would be in career interests. STEPS camp changed my life, and I hope that I have helped another young girl realize that maybe the engineering field is for her. This camp has an amazing mission, and I am very happy to have helped achieve this.” —*Madeline H.*

A measure of the success of the STEPS program is the continued demand for the program. The program reaches its capacity of 160 participants each year and maintains a waiting list of hopeful applicants. Requests are received for the following year as soon as—if not before—the current year is finished. The junior counselor and lab assistant positions have become so popular that about 60 applications are received each year for 16 or 18 positions, respectively.

A survey administered to the alumnae following these experiences indicates that all participants enjoyed the experience, learned something new, and planned to go to college or pursue education past high school. Responses also indicate that almost 42% of participants are interested in attending the UW-Stout for that education. About 42% of these alumnae expressed an interest in pursuing a career in science, 33% a career in engineer and technology and the rest in education.

During the past 15 years, STEPS has evolved from an introduction to the world of manufacturing to a program encourages and inspires girls and young women to take the



courses necessary to prepare for citizenship and work in a technological society. It provides opportunities to support the alumnae at critical points in the human development process.

### **Suggestions for best practices**

The survey data shows that a hands-on, minds-on learning approach through the designing, building and testing of a manufactured product is a key component of the success of the program. The product itself does not seem to be as critical as the creation of experiential learning activities that are fun and attend to female pedagogy. Many parents also have expressed an interest in attending the program themselves.

Pedagogy is the “art, science or profession of teaching” as related to the “knowledge and development resulting from an educational process.”<sup>17</sup> Research conducted by social psychologists provides a foundation for structuring learning activities based on diversity in development based on gender. This diversity has implications that reach far beyond chromosomal, hormonal and genital differences. Although the issues surrounding gender are still somewhat controversial, the current research provides theoretical perspectives for the development of learning activities that attend to this gender diversity.<sup>18</sup>

Appropriate facilities, faculty and funding are also necessary to the overall success of the program and must be maintained each year to ensure a high level of quality. Several attempts to replicate the STEPS program by institutes without adequate facilities have failed. The facilities that are usually deficient include a foundry, a plastics laboratory, a metal forming and material removal laboratory and a packaging laboratory. Because the STEPS curriculum is an interactive learning environment, it is important to have facilities and equipment that allow the participants a hands-on, minds-on learning activity. A dedicated and passionate group of faculty provides the year-round energy needed to plan, organize, implement and assess the success of this program.

Lastly, and most importantly, a sustainable source of funding, as well as an economically conscientious budget that looks beyond purchase and production is crucial to the best practices for longitudinal program survival. To maintain the utmost quality in each of these areas, a



continuous improvement process is vital. At a minimum, this should include an annual lessons learned review immediately following the completion of the summer program's final session.

### **Program success**

STEPS for Girls is an unqualified success. The UW-Stout, with the assistance of sponsors, will continue to offer this excellent program. Advanced STEPS for Girls builds on the success of the seventh grade program experience and provides a 10th grade design experience. Advanced STEPS, junior counselor and lab assistant experiences will further solidify the career choices into engineering and technology. This summer program will continue to achieve the primary goal of attracting and encouraging women to pursue engineering and technology careers. In addition, STEPS for Girls participants have developed an overall appreciation of STEM subjects even if they choose other career pursuits.

Through pre and post-experience surveys, STEPS for Girls and Advanced STEPS participants have shown they leave STEPS for Girls with a high level of appreciation for the kind of work a scientist or engineer performs, and this knowledge is retained when they return for Advanced STEPS. The survey results also indicate that STEPS for Girls doubles the interest in pursuing an engineering or scientific career. The Advanced STEPS surveys indicate that the group of selective students participating is better than 50% likely to pursue a career in engineering or science.

While the quantitative data presented indicates the success and worthiness of STEPS for Girls, some of the best evidence in support of this program is qualitative. The following unsolicited quote came from a parent:

"My daughter attended STEPS for Girls two summers ago ... She has gained so much from it I can't put it into words. Her self-confidence has skyrocketed to the moon. Her grades have followed. Previous grades were 2.5- 2.7 range. Since STEPS, they are 3.7- 4.0. Yes, straight A's a couple times. Our entire family attributes the change to the STEPS for Girls Program. She is a real leader and go-getter the last couple of years. She always tells us that 'she found out that she wasn't dumb' at the camp. No other



changes in her life. She has surrounded herself with great friends and consistently gets high remarks from her instructors in school. Truly an amazing life change for her.”

UW-Stout deems this program to be exceptional and encourages all universities to consider developing an outreach activity modeled after STEPS for Girls and Advanced STEPS.

### **Looking to the future**

Planning has begun on a collaboration project with the school of education at UW-Stout to create professional development opportunities for in-service teachers related to promoting gender equity in STEM subjects. The proposed collaboration aspires to “improve teachers’ abilities to attract and mentor female students in STEM-related career paths by:<sup>19</sup>

- Providing professional development related to increasing knowledge related to creating a “gender equitable” pipeline for young women entering STEM fields.
- Providing professional development in evidence-based factors influencing female participation in STEM-related courses.
- Developing “best practices” that encourage female participation in STEM activities.
- Conducting classroom-based research relative to identified best practices.
- Building collaborative relationships among project participants.

Development and initial implementation is anticipated to take about one year. The first professional development workshops are proposed to take place during STEPS 2013. Compilation and planning for dissemination of the initial results will begin during the fall of 2013.

Two new initiatives are being developed to provide further information and encouragement to all STEPS alumnae about opportunities for women in STEM areas and attempt to track the alumnae longitudinally.



First, updates to the STEPS website at [www.uwstout.edu/steps](http://www.uwstout.edu/steps) will allow alumnae to update contact information, complete surveys and apply for positions online. The other is a collaboration project with UW-Stout's admissions office to offer more concrete career information and track those STEPS alumnae who enroll in programs at UW-Stout.

A plan to pursue sustainable funding sources for the future of the STEPS program is being developed. Financial support for the program has declined in spite of the program's success. Various economic instruments are being investigated, including grants, sponsorship, tuition rates and donations.

A new autonomous robot project, the Beetle Bot, is being developed to replace the boat project. The Beetle Bot is scheduled to begin production during STEPS in 2013. The largest benefit this product change will provide is related to material availability and cost. Other benefits to the curriculum include retention of rigor within STEM concepts, and more time for manufacturing processes and concept presentation.

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